SUSPENSION CRITERIA FOR IMAGE MONITORS AND VIEWING BOXES.

Tingberg, Anders

Published in:
Radiation Protection Dosimetry

DOI:
10.1093/rpd/ncs302

2013

Radiation Protection Dosimetry (), Vol. 0, No. 0, pp. 0–0
DOI:

SUSPENSION CRITERIA FOR IMAGE MONITORS AND VIEWING BOXES

A. Tingberg[1,2]
[1]Radiation Physics, Skåne University Hospital, 205 02 Malmö, Sweden
[2]Department of Medical Radiation Physics, Lund University, Skåne University Hospital, 205 02 Malmö, Sweden

Image monitors and viewing boxes have a crucial role in the diagnostic process. Modern radiology uses different modalities to produce digital images which are to be viewed in different parts of the radiology department and throughout the hospital, sometimes simultaneously, via the Picture Archiving and Communications System (PACS). Therefore, the quality of the image monitors is of great importance. IPEM notes that inadequacies in the imaging viewing area may serve to negate the benefits of other efforts made to maintain quality and consistency. Suspension criteria for diagnostic image monitors and viewing boxes are presented in RP162. These criteria are mainly based on two documents, IPEM report 91, "Recommended standards for the routine performance testing of diagnostic x-ray imaging systems", (2005) and AAPM on-line report no. 03, "Assessment of display performance for medical imaging systems", (2005). The development of common European suspension levels for image monitors and viewing boxes will be a valuable tool in quality assurance.

INTRODUCTION

Image monitors and viewing boxes have a crucial role in the diagnostic process as they represent the last stage of the medical imaging chain. In modern diagnostic radiology, digital images are produced using different modalities from different vendors, which are to be viewed on digital image monitors in different parts of the radiology department and possibly throughout the whole hospital, sometimes simultaneously, via the Picture Archiving and Communications System (PACS). The quality of the image monitors in a radiology department must be similar and good-enough, so that the diagnosis do not depend on which workstation was used for making the diagnosis. In a radiology department which has not been digitized, the same goes for the quality of the viewing boxes.

The European Commission Report Radiation Protection no 91 (RP91)[(1)] contains a short passage referring to the quality of viewing boxes. Criteria on minimum luminance and maximum inhomogeneity of viewing boxes and the maximum level of ambient light are presented. As this report was published in 1997, there is no information on acceptance criteria of digital image monitors as digital radiography was only in the beginning of becoming a *de facto* standard across Europe. With the publication of the report by AAPM TG 18[(2)], the level of knowledge related to digital monitor testing increased substantially. This report contains a lot of useful information on monitors and how to test them. However, there is a need to develop acceptance levels and suspension criteria for image monitors and viewing boxes that are valid for the current equipment available across Europe. The recently available draft report Radiation Protection no 162 (RP162) which is intended to replace RP91, describes acceptability levels and suspension criteria for viewing boxes for conventional radiography and mammography, and for digital image monitors for conventional, for dental x-ray imaging and for mammography.

The diagnostic process is a complicated series of events that all contribute to the resulting image quality presented to the observer. The object (patient) is exposed to x-rays which are partly transmitted and captured by the imaging system. The performance of the imaging system is governed by the detective quantum efficiency (DQE). In digital radiography the captured photon distribution is converted into a raw image which is processed with various, often vendor-specific, algorithms depending on the body part that was imaged, and to some extent, the preference of the user. In analogue radiography, the captured photon distribution is converted to different density levels through the development of the film. The final step, the display of the images to the observer is as crucial as the other steps, although it is sometimes forgotten in QA programs. An image monitor or viewing box must operate at an optimum performance level; otherwise optimization of the other stages of the imaging chain may be jeopardized or even nullified[(3)].

The draft version of RP162 presents suspension criteria for various parameters related to image monitors and viewing boxes. Failure to meet a suspension level requires that the equipment is taken out of service immediately until it is restored to satisfactory performance. An alternative to suspending equipment

*Corresponding author: anders.tingberg@med.lu.se

is to restrict it for less demanding tasks for which a lower specification of performance is acceptable. Before this decision, a risk assessment should be done by the medical physics expert and the practitioner. Tables 1-4 present the suspension criteria for image monitors and viewing boxes given in RP162.

The purpose of this paper is to present the newly proposed suspension levels of RP162 and to give an example of how these suspension levels are applied when testing an image monitor for mammography. The intention of this paper is not to give a full overview of existing methods for monitor quality evaluation, or to present results from measurements on a wide range of viewing devices.

MATERIAL AND METHODS

To test the applicability of the suspension criteria for image monitors for mammography presented in RP162, performance testings of an image monitor for mammography (Eizo SMD 21510D, 5MP, Karlsruhe, Germany) was carried out when the monitor was brand-new. The measurements were repeated a year later. For the luminance measurements described in this paper, a telescopic photometer (Konica Minolta Luminance meter LS-100, Osaka, Japan) was used together with various test patterns developed by AAPM TG 18. For some of the tests described in this paper, the test patterns were used for visual inspection. The test patterns are available for download from http://www.aapm.org/pubs/reports/OR_03_Supplemental/. For all the measurements described in this paper, the room illumination was switched off to mimic clinical conditions as close as possible. The ambient light level was less than 5 lux. The test of distance and angle calibration was not performed, as this test is designed for cathode ray tube (CRT) monitors. With the fixed pixel matrix of LCD and similar monitors, distances and angles are considered to not change over time. The test of variation between adjacent monitors was not performed either, as the tests described in this paper was only performed on one single image monitor.

Luminance ratio

The greyscale ratio or luminance ratio is defined as the ratio of the maximum luminance from a monitor to the minimum luminance in the presence of ambient light[2]. The two test patterns AAPM TG18-LN12 01 and AAPM TG18-LN12 18 were displayed on the monitor. The photometer was positioned to simulate the location of the eye of an observer and aimed at the centre of the pattern and the luminance was measured (Figure 1).

Contrast resolution

Contrast resolution is evaluated by examining the visibility of the 5% and 95% patches of the test pattern AAPM TG18 QC (indicated by black and white circles, Figure 2). If these two patches are visible, then the contrast resolution is deemed sufficient.

Spatial resolution

The spatial resolution of the image monitor can be evaluated with different methods. In this paper, the AAPM TG 18 QC pattern was examined. The appearance of the CX patterns in the centre and in the four corners (Figure 2) were examined and compared to the scoring scale (the series of large Cx patterns in the centre of the pattern)[4]. Furthermore, the line pair patterns in the centre and the four corners of the image are inspected. As there is no absolute suspension level given in RP162, the suspension level presented by AAPM[2] is used in this paper (Cx should be between 0 and 4).

DICOM greyscale

The measured luminance response of the monitor at different greyscale levels (pixel values) is compared to the theoretical DICOM greyscale standard display function (GSDF)[5]. The 18 test patterns AAPM TG18-LN12 01 to 18 are displayed on the monitor one at a time and the luminance is measured for each of these test patterns. The pixel values are converted into JND-indices and then the luminance response curve can be plotted.

Uniformity

The uniformity of a monitor is defined by equation (1).

$$\text{Uniformity}=200*(L_{max}-L_{min})/(L_{max}+L_{min}) \quad (1)$$

The uniformity is determined by measuring the luminance in the centre and in the four corners of the monitor at two different luminance levels, dark and bright. The two test patterns TG18-UNL10 and TG18-UNL80 (Figure 3) are used for this measurement.

RESULTS

When the mammography monitor was new, it passed all tests that were performed in this study. The greyscale ratio of the monitor was 420 cd/m^2 / 1.18 cd/m^2 = 356 which is clearly above the suspension criteria, 250. The contrast patches of the test pattern AAPM TG18 QC were easily discernible and thus the contrast resolution was sufficient. For the spatial resolution, the Cx-pattern test yielded the highest possible score. Also the line pair patterns were perfectly displayed. The measured luminance response curve compared to the DICOM GSDF is shown in

Figure 4. The response curve was always within +/- 10% of the theoretical DICOM GSDF curve. The uniformity measured in both the dark and the bright image was 12% which is well below the suspension level (30%). However, when the monitor had been used for a year, its performance had changed. The grayscale ratio had decreased to 226, which is below the suspension level. The monitor passed the tests of contrast and spatial resolution. The luminance response curve was outside the acceptable limit. The uniformity had also degraded (26% in the dark region and 17% in the light region). These values were, however, below the suspension level for uniformity. As a result of the measurements presented in this paper, the monitor was calibrated which led to acceptable performance.

DISCUSSION

The development of European suspension levels for image display is an important step towards national quality control programs that rely on an established scientific foundation. Before the publication of RP162 there was no document that was up-to-date and covered the whole field of diagnostic radiology. For the quality assurance of image monitors, the AAPM TG 18 report is an excellent source of knowledge; the technical description of image monitors, the detailed descriptions of test procedures and of the test images that was developed within this task group. The suspension levels presented in RP162 is a good complement to the AAPM report.

A limitation of the suspension criteria for image monitors and viewing boxes presented in RP162 is that there is no suspension level for ambient light. This is an important parameter for a good image viewing environment. The suspension criteria are referring to the quality of a specific piece of equipment (e.g. the image monitor or viewing box), and therefore it would be meaningless to suspend an image viewing device because of a too high level of ambient light. Still, the author believes that there should be a suspension criterion for this parameter as well. As the quality of the viewing device is closely connected to the viewing environment it would still be meaningful to advice on acceptable levels of ambient light.

In this paper, the test procedures that accompany the suspension levels were used on a mammography LCD monitor when it was brand-new and a year later. The purpose of this was to demonstrate how to use the tests and how the suspension levels should be applied. As expected, the monitor passed all tests that were performed when it was new. When the monitor had been used for a year, it failed some of the tests. The results of the measurements detected that the monitor needed to be calibrated, before the mammographers had noticed the degradation of performance. After calibration, the performance of the monitor was again within the acceptable limits. Measurements on a newly calibrated diagnostic monitor for general radiography (not presented here) showed that this monitor met the suspension criteria presented in Table 1. This suggests that the recently developed suspension criteria are sensitive enough to detect an image monitor which needs to be calibrated.

CONCLUSIONS

The development of common European suspension levels for image monitors and viewing boxes will be a valuable tool in quality assurance. The suspension criteria are sensitive enough to detect image monitors that need to be calibrated.

ACKNOWLEDGEMENTS

The author wishes to thank Sören Mattsson for critically reviewing and improving the manuscript.

REFERENCES

1. European Commission (EC). Radiation protection 91. Criteria for acceptability of radiological (including radiotherapy) and nuclear medicine installations. (Luxembourg (1997) ISBN 92-828-1140-9.
2. American Association of Physicists in Medicine (AAPM). Assessment of display performance for medical imaging systems. AAPM on-line report 03 (2005).
3. Institute of Physics and Engineering in Medicine (IPEM). Recommended Standards for the Routine Performance Testing of Diagnostic X-Ray Imaging Systems, Report 91 (2005).
4. Kohm, K., Cameron, A. W. and Van Metter, R. L. Visual CRT sharpness estimation using a fiducial marker set. Proceedings of SPIE. 4319, 286-297 (2001).
5. Digital Imaging and Communications in Medicine (DICOM), Part 14: Grayscale Standard Display Function, National Electrical Manufacturers Association (1999).

TABLES

Table 1. Suspension Levels for Diagnostic Monitors (excluding Mammography)

Physical Parameter	Suspension Level
Luminance ratio	<200
Distance and angle calibration – distortion (for CRT)	>10%
Monitor spatial and contrast Resolution	Visual inspection of test pattern image (low and high contrast resolution)
DICOM greyscale (GSDF= DICOM Greyscale Standard Display Function)	>GSDF ±15%
Uniformity	>40%
Variation between adjacent monitors	>40%

Table 2. Suspension Levels for Diagnostic Monitors for Mammography

Physical Parameter	Suspension Level
Luminance ratio	<250
Distance and angle calibration – distortion (for CRT)	>10%
Contrast resolution	If 5% and 95% contrast patches of the TG18 QC test pattern not discernible
Spatial resolution	Outside specification of vendor
DICOM greyscale (GSDF= DICOM Greyscale Standard Display Function)	Deviations from GSDF>±10%
Uniformity	>30%
Variation between adjacent monitors	>10%

Table 3. Suspension Levels for Viewing Boxes (excluding Mammography and Dental systems)

Physical Parameter	Suspension Level
Luminance	Outside the range of 1500 - 3000 cd/m^2
Uniformity	>30%
Variation between adjacent viewing boxes	>30%

Table 4. Suspension Levels for Viewing Boxes for Mammography

Physical Parameter	Suspension Level
Luminance	< 3000 cd/m2
Uniformity[1]	
Variation between adjacent viewing boxes	>15%

[1]No value is presented in RP 162.

FIGURE CAPTIONS

Figure 1. Measurement of maximum and minimum luminance with a telescopic photometer. In this paper, results from measurements of only one of the monitors are presented.

Figure 2. The test pattern AAPM TG 18 QC with the 5% and 95% patches marked.

Figure 3. The test patterns TG18-UNL10 (left) and TG18-UNL80 (right) which are used for estimation of uniformity.

Figure 4. Measured luminance response of the mammography monitor when it was new (year 0) and one year later (year 1), compared to the DICOM greyscale standard display function.

FIGURES

Figure 1. Measurement of maximum and minimum luminance with a telescopic photometer. In this paper, results from measurements of only one of the monitors are presented.

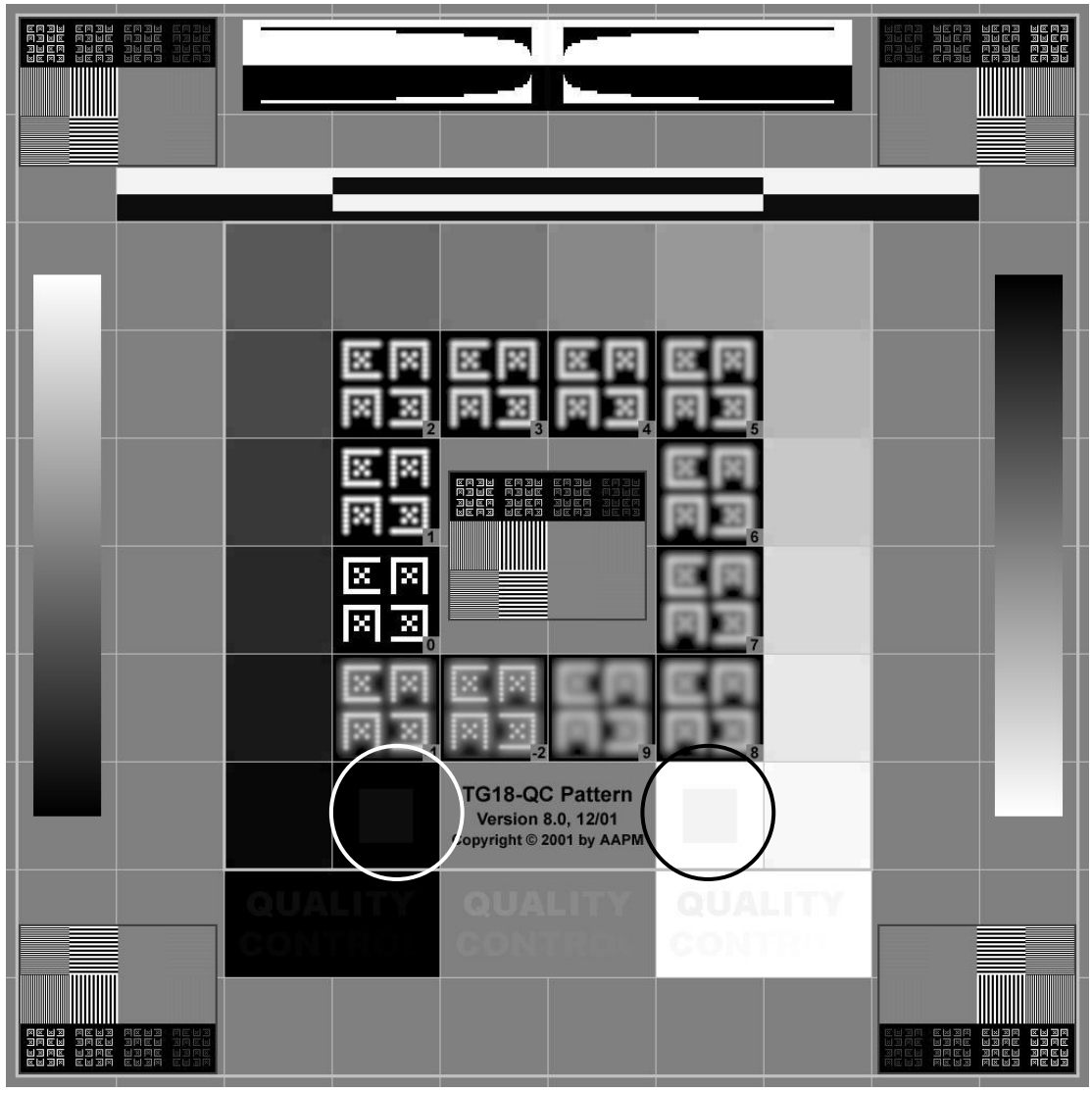

Figure 2. The test pattern AAPM TG 18 QC with the 5% and 95% patches marked.

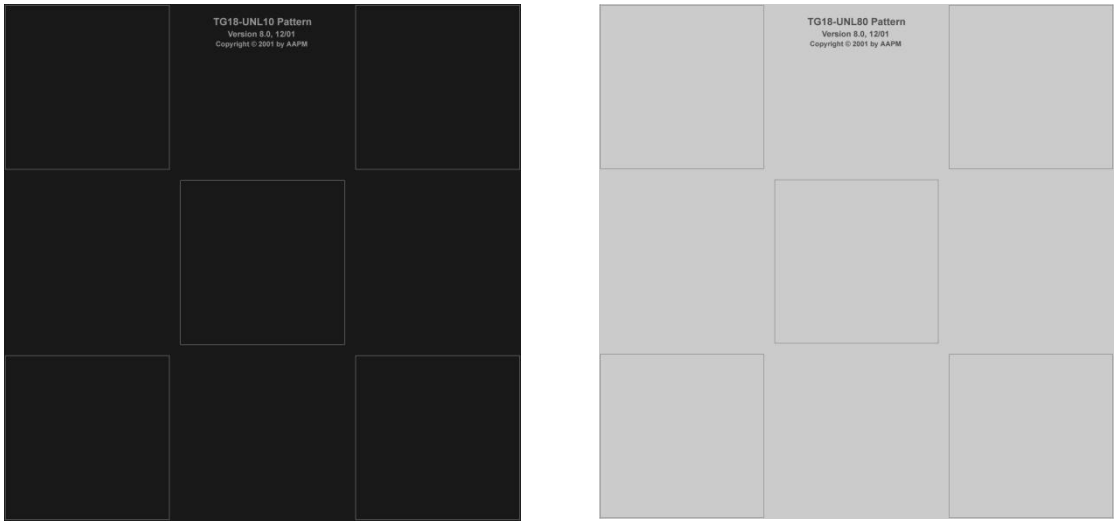

Figure 3. The test patterns TG18-UNL10 (left) and TG18-UNL80 (right) which are used for estimation of uniformity.

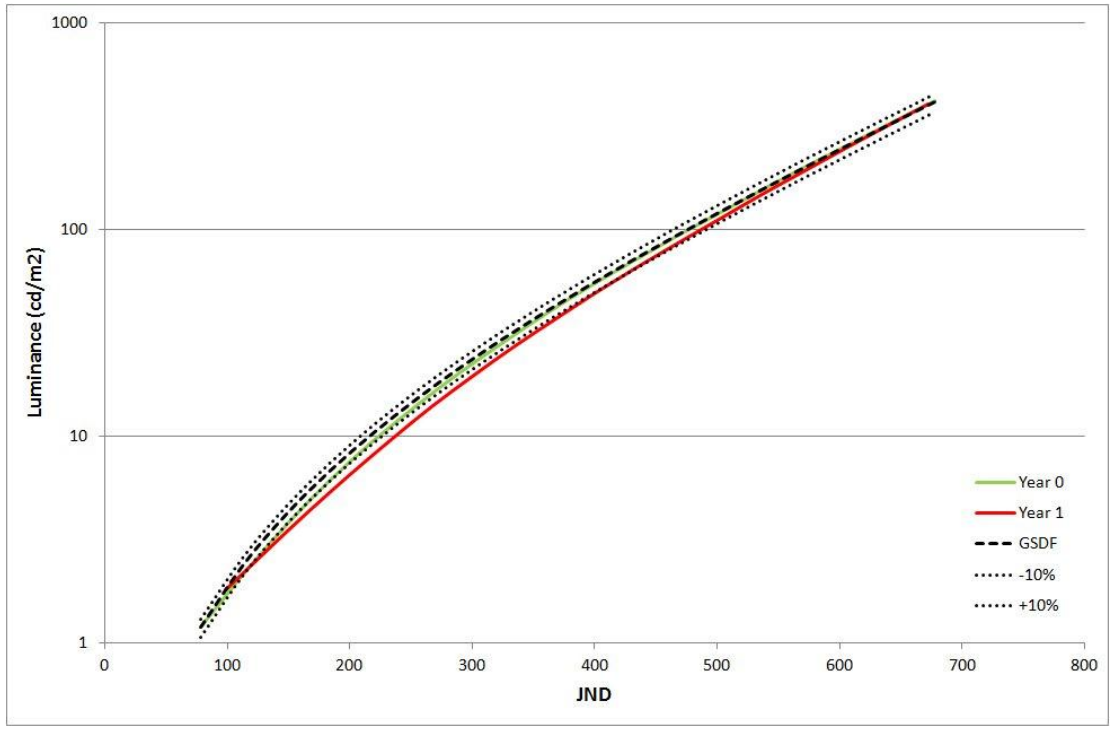

Figure 4. Measured luminance response of the mammography monitor when it was new (year 0) and one year later (year 1), compared to the DICOM greyscale standard display function.